Pribory i metody dlia izuchenila elektrichestva atmosfery

(Instruments and methods for investigating atmospheric electricity),
Moscow, Gostekhizdat, 1957. 484 pp., cloth.

by

I. M. Imianitov

Translator: David Kraus
April 1961

Translated for Geophysics Research Directorate, Air Force Research Division, L. G. Hanscom Field, Bedford, Massachusetts, by the American Meteorological Society, Contract number AF 19(604)-6113.

M-RTC-29+

Imianitov, I. M. Pribory i metody dlia izucheniia elektrichestva atmosfery (Instruments and methods for investigating atmospheric electricity), Moscow, Gostekhizdat, 1957. 484 pp. cloth. 13 rubles 80 kopeks (about $1.50)

TABLE OF CONTENTS

Chapter 5. (cont'd)

INTRODUCTION

Wall's proposal (1708) that a spark and a lightning flash are identical could not be verified for many years, because there were no instruments and methods of direct measurement. Detailed study of atmospheric electricity was begun by M. V. Lomonosov, G. V. Rikhman, T. Dalibard and other scientists, who were able to show the electric nature of thunderstorm phenomena such as lightning and thunder and who developed the necessary apparatus for such studies. For example, Rikhman constructed the world's first electrometric instrument designed for such measurements, an electroscope for measuring "electric force." By means of this electroscope, which was the best electrometric instrument of the time, and Lomonosov's "thunder machine," it was established that atmospheric electricity also exists in absence of thunderstorm clouds. This fact formed the basis for an entire branch of atmospheric electric research.

The development of science and technology, chiefly meteorology, aviation, electronics and radio engineering and their numerous subdivisions, has greatly expanded our knowledge of atmospheric electricity.

High, conductive layers of the atmosphere were discovered, namely the ionosphere; powerful sources of atmospheric ionization were revealed, viz. cosmic rays; the electric nature of polar aurorae was established, etc. Investigations of the electric properties of the entire atmosphere were begun. At present, ever greater attention is being paid the study of the electric properties of the atmosphere, because of the demands of the most diverse branches of theoretical and applied science.

To arrive at a reliable forecast of thunderstorms and the tendencies of thunderstorm processes, one must know the laws of cloud charges, chiefly those of thunderstorm clouds. This is required to safeguard the ever expanding network of high-power transmission lines, to insure radio communications, especially aircraft radio communications, since radio interference during flights in clouds and precipitation increases as the third power of the flightspeed, and the flight speeds of modern airplanes are being increased continually. Exploratory geophysics, which is greatly extending the search for radioactive ores, encounters the electrical properties of the atmosphere. Upper atmospheric flights are also concerned with these same problems.

With the expansion of investigations has come the demand for development of instruments and methods of observing atmospheric electricity. At present, extensive study is being devoted to such electrical properties of the atmosphere as conductivity, permittivity,the distribution of ion mobilities (ion spectrum), the charges of individual particles and volume charges, electrostatic and electromagnetic fields, electric currents, electron concentration in the ionosphere, the strength of various sources of ionization, cosmic radiation, terrestrial and atmospheric radioactivity, electrification during the disintegration of particles (ball-electric effect) and during phase conversions of water, etc.

In conducting such investigations, one must use apparatus which will take into account a number of the specific properties of atmospheric electric measurement. One of these special features is the exceptionally wide range of measurable values. For example, the vertical currents in the atmosphere may vary from hundreds to hundreds of thousands of amperes. Conductivity charges from 10^{-6} to 10^{-4} ohm^{-1} at the earth's surface to 10^{7} - 10^{8} ohm^{-1} at a height of approximately 100 km, etc. Therefore, the measuring apparatus must have a number of sensitivity ranges. The operating principle of the instruments for measuring lightning currents must differ from that of instruments for measuring vertical currents, while instruments for measuring atmospheric conductivity at the earth's surface differ considerably from those used to measure ionospheric conductivity.

Another feature of most atmospheric electric observations is the need for measuring very small currents under complex meteorological conditions: low temperature, high relative humidity, precipitation, etc., while small currents of this type are often difficult to measure even under controlled laboratory conditions.

A characteristic feature of atmospheric-electric measurements is that the investigated phenomenon is not reproducible. This means that the measuring apparatus must be highly accurate, since the measured values cannot be refined by subsequent repetition of the measurements, as can usually be done in laboratory studies. Generally speaking, most atmospheric-electric phenomena cannot be reproduced under laboratory conditions.

In a number of cases, the measurements are seriously complicated by the suddeness and brevity of the phenomena. For example, lightning flashes last from several tens of microseconds to several hundreds of milliseconds and follow each other in time intervals from tens of seconds to tens of minutes. In this case, the measuring apparatus must be tuned to the correct measurement band during the flash and must be prepared to record the process at any moment. Obviously, such an apparatus is impossible without the highest degree of automation.

It is difficult to make measurements of atmospheric electricity in such poorly accessible regions as the ionosphere and thunderstorm clouds. Often it is dangerous to make measurements in thunderstorm clouds. In any event, measurement conditions are complicated when highly stable, reliable automatically recording apparatus is required.

Finally, many atmospheric-electric investigations involve prolonged continuous measurements which require apparatus that will provide reliable measurements for decades.

Often these complex requirements are imposed simultaneously and thus one must have highly accurate atmospheric-electric measurement apparatuses which employ all the possibilities of measurement technique. Mechanical, tube and dynamic electrometers, electrostatic fluxmeters, ionization chambers, ionized-particle counters, cathode-ray oscillographs (for recording rapid processes), pulse radar devices (for studying the ionosphere) and other devices have been built to study atmospheric electricity. This book may be of interest not only to those directly involved in atmospheric-electric measurements, but also to researchers in other branches of science and technology in which electrostatic measurements, measurements of small currents, et al. are made.

In compiling this book, we have kept in mind that some branches of atmospheric-electric measurement have been treated in detail in special literature (e.g., measurement of ionization and lightning currents), while other branches have only been described in journal articles (e.g., measurement of field strength, vertical currents, atmospheric conductivity, i.e., electrostatic measurements and measurements of weak currents) and we have devoted special attention to subject matter not covered thoroughly in special literature.

Chapter 12 "Investigation of the upper atmosphere" was written by L. G. Makhotkin.